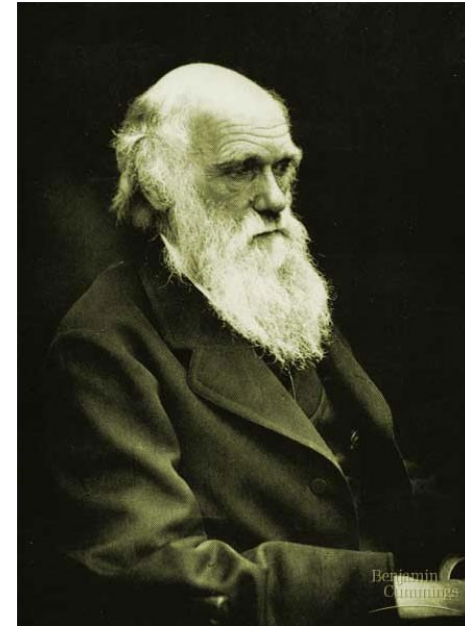




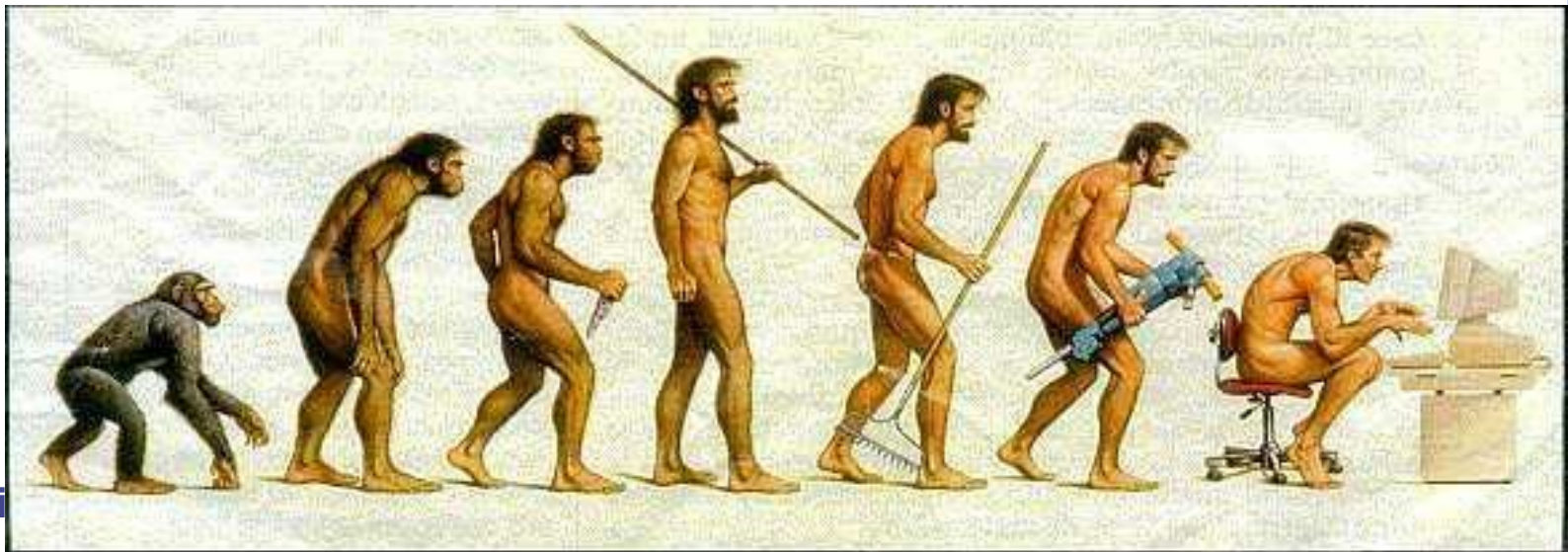
# evolution

*a journey into where we're from  
and where we're going*



## Chapter 22.

# Evolution by Natural Selection





**"Nothing in biology  
makes sense except in  
the light of evolution."**

---

**-- Theodosius Dobzhansky**  
**March 1973**  
**Geneticist, Columbia University**  
**(1900-1975)**



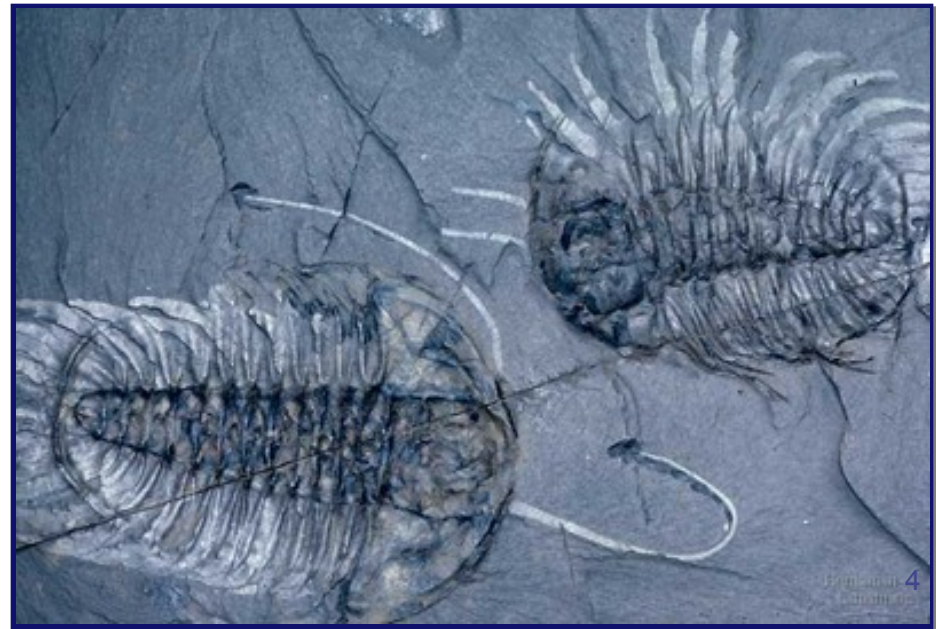


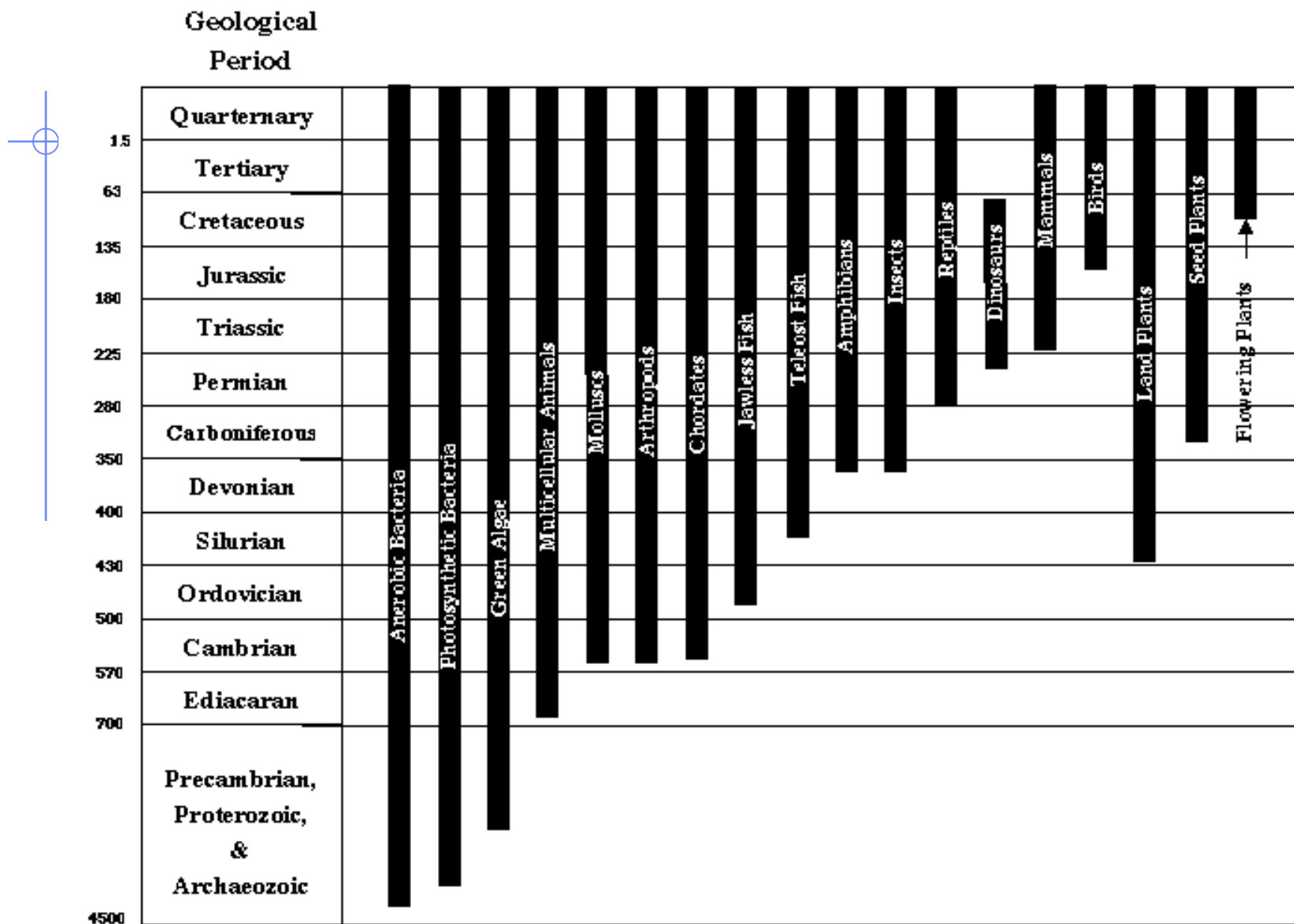
**TINTORETTO**

*The Creation of the Animals 1550*

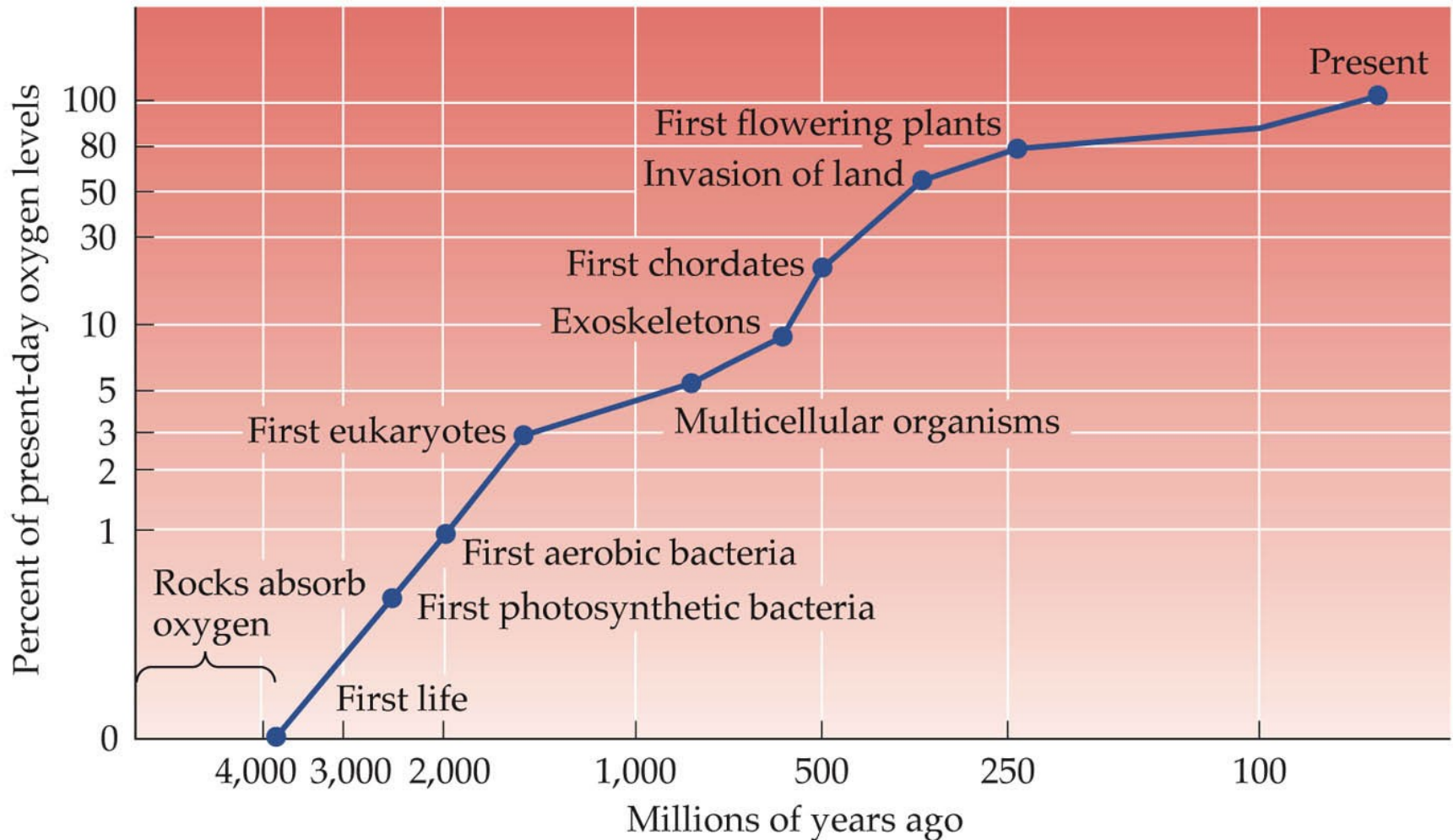


# Fossil record?





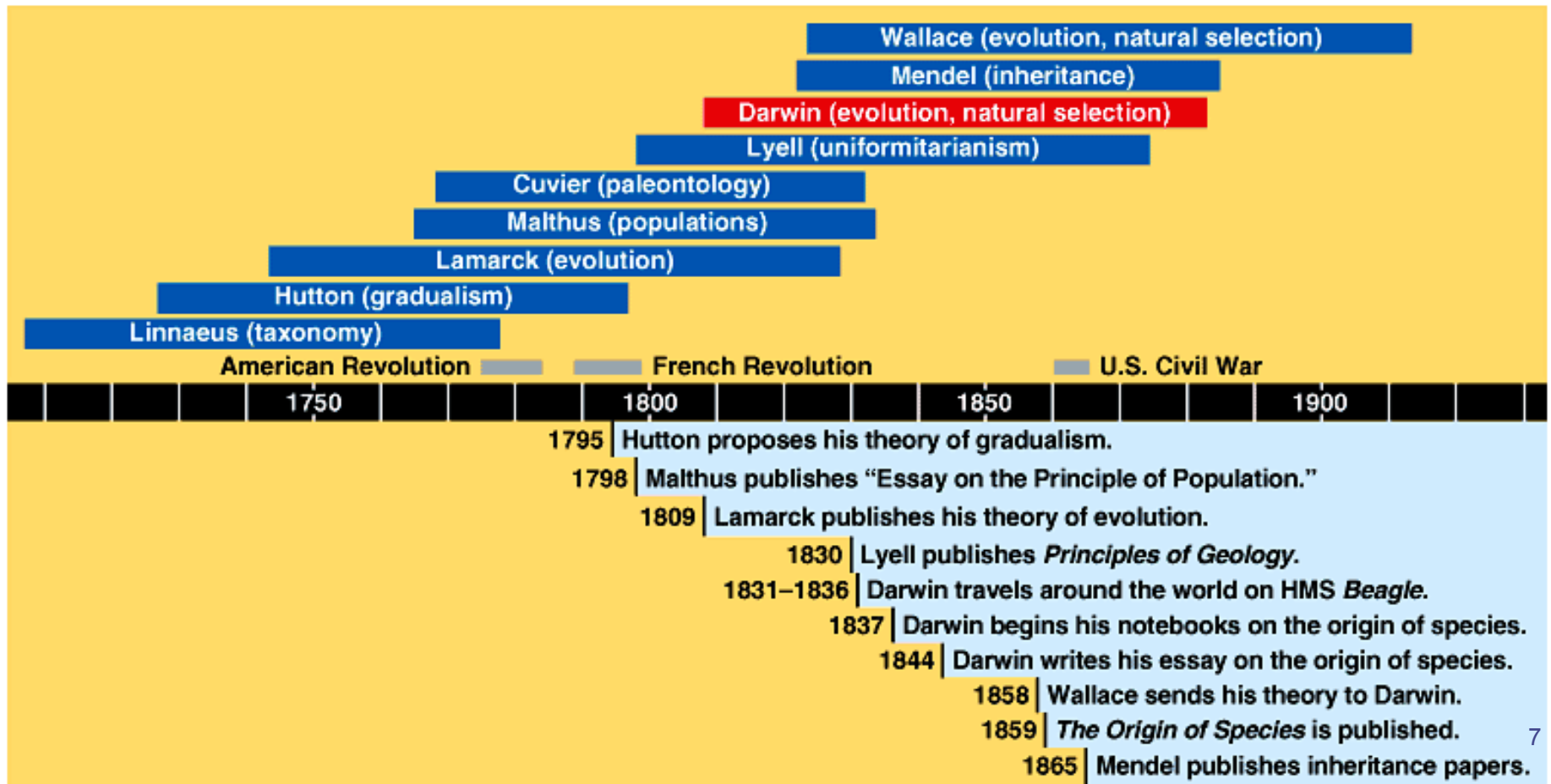
# Evolution of life has altered the Earth





# In historical context

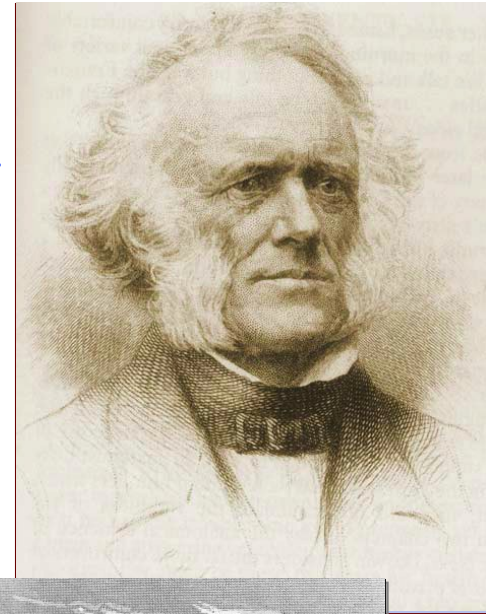
- Darwin did not originate the idea of evolution
- Geologic theories of Earth's history cleared the path for evolutionary biologists



# Geologic theories

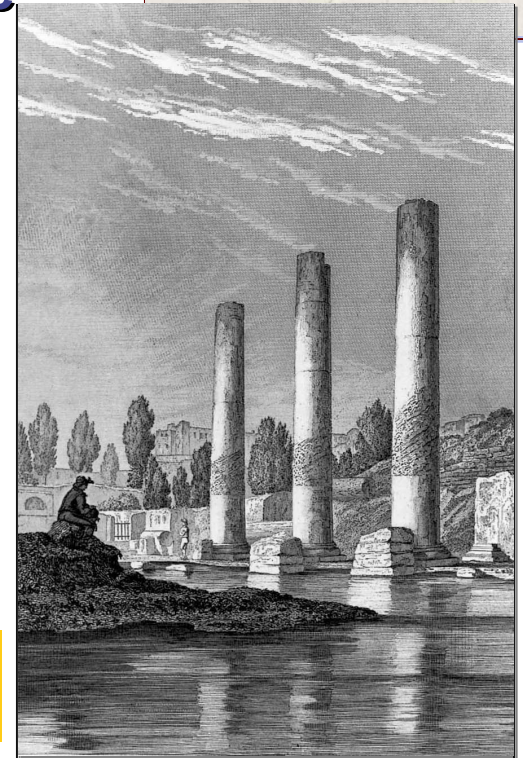
## ■ Charles Lyell (1797-1875)

- ◆ studied the Temple of Scrapis (Sicily)
- ◆ built on land & used until 200AD
- ◆ high tide now above temple floor
- ◆ holes in columns well above high tide



### Meaning:

In less than 2000 years, temple sunk well below sea level, and then was raised up again — natural processes and immense periods of time could produce great changes.



**“the present is the key to the past”**



# **“Succession of types”**

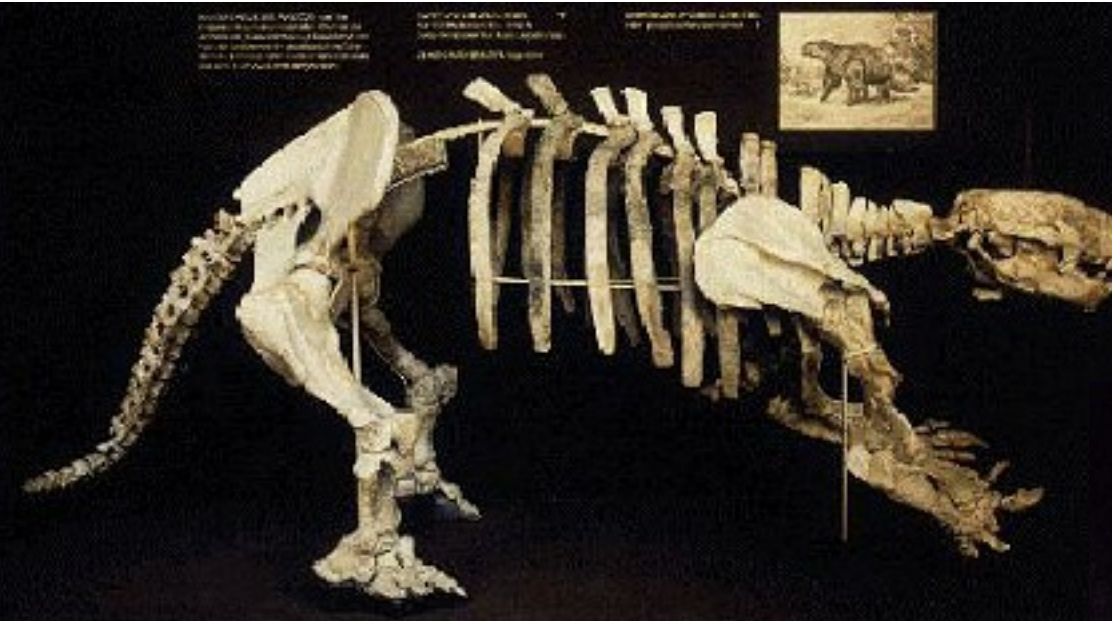
**Armadillos are native to the Americas, with most species found in South America.**



**Glyptodont fossils also unique to South America.**

**Why should extinct armadillo-like species & armadillos be found on same continent?**

**Mylodon (left) Giant  
ground sloth (extinct)**



**Modern sloth (right)**



***“This wonderful relationship in the same continent between the dead and the living will, I do not doubt, throw more light on the appearance of organic beings on our earth, and their disappearance from it, than any other class of facts.”***

**Chapter 8, Voyage of the Beagle**



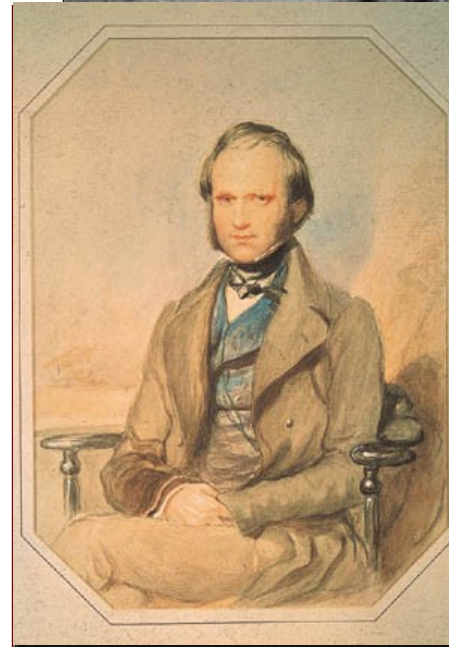
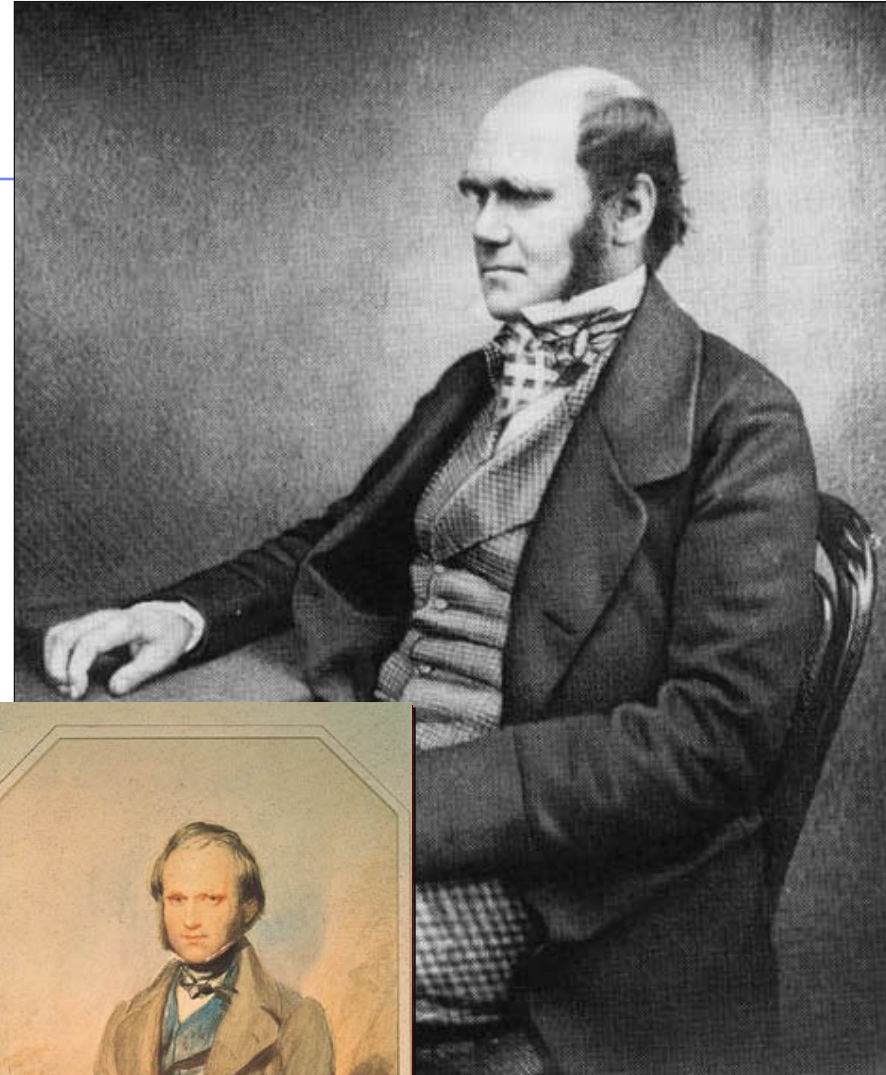
# LaMarck

- Organisms were adapted to their environments
  - ◆ adaptation is a result of change caused by environmental pressures
    - **Use & Disuse**  
organisms lost parts because they did not use them — like the missing eyes & digestive system of the tapeworm
    - **Perfection with use & need**  
the constant use of an organ leads that organ to increase in size — like the muscles of a blacksmith or the large ears of a night-flying bat
      - ◆ evolution of acquired characteristics



# Charles Darwin

- 1809-1882
- British naturalist
- Proposed the idea of evolution by natural selection
- Collected clear evidence to support his ideas





# Voyage of the HMS Beagle

- Travels around the world
  - ◆ 1831-1836
  - ◆ makes many observations of natural world
    - main mission of the *Beagle* was to chart South American coastline

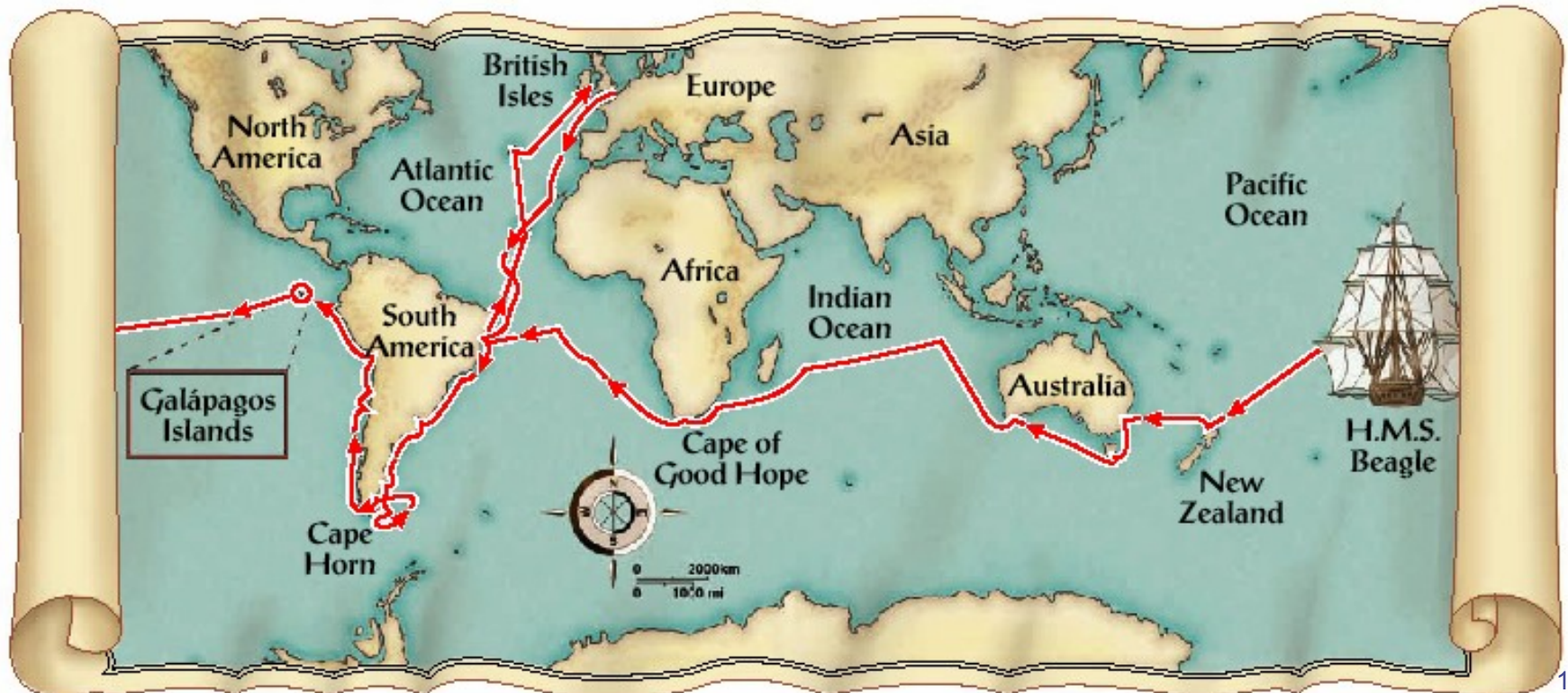


**Robert Fitzroy**



# Voyage of the HMS Beagle

- Stopped in Galapagos Islands





## A

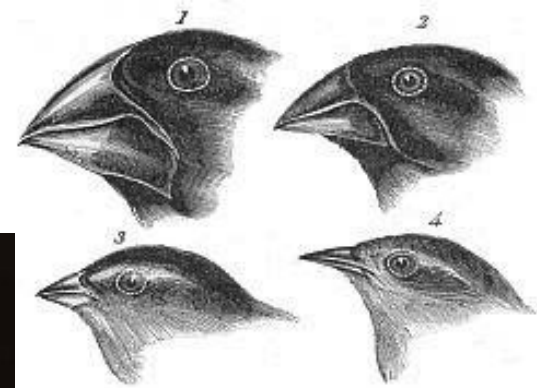
A



A



# Unique species



1. *Geospiza magnirostris*  
3. *Geospiza parvula*

2. *Geospiza fortis*  
4. *Certhidea olivacea*

Finches from Galapagos Archipelago



# The Birds...

- **Galápagos birds**
  - ◆ 22 of the 29 species of birds on the Galapagos are *endemic*
    - found only on these islands
  - ◆ collected specimens of all
- **One particular group...**
  - ◆ at first, he paid little note to a series of small but distinctive birds
  - ◆ some were woodpecker-like, some warbler-like, & some finch-like





# Darwin's finches

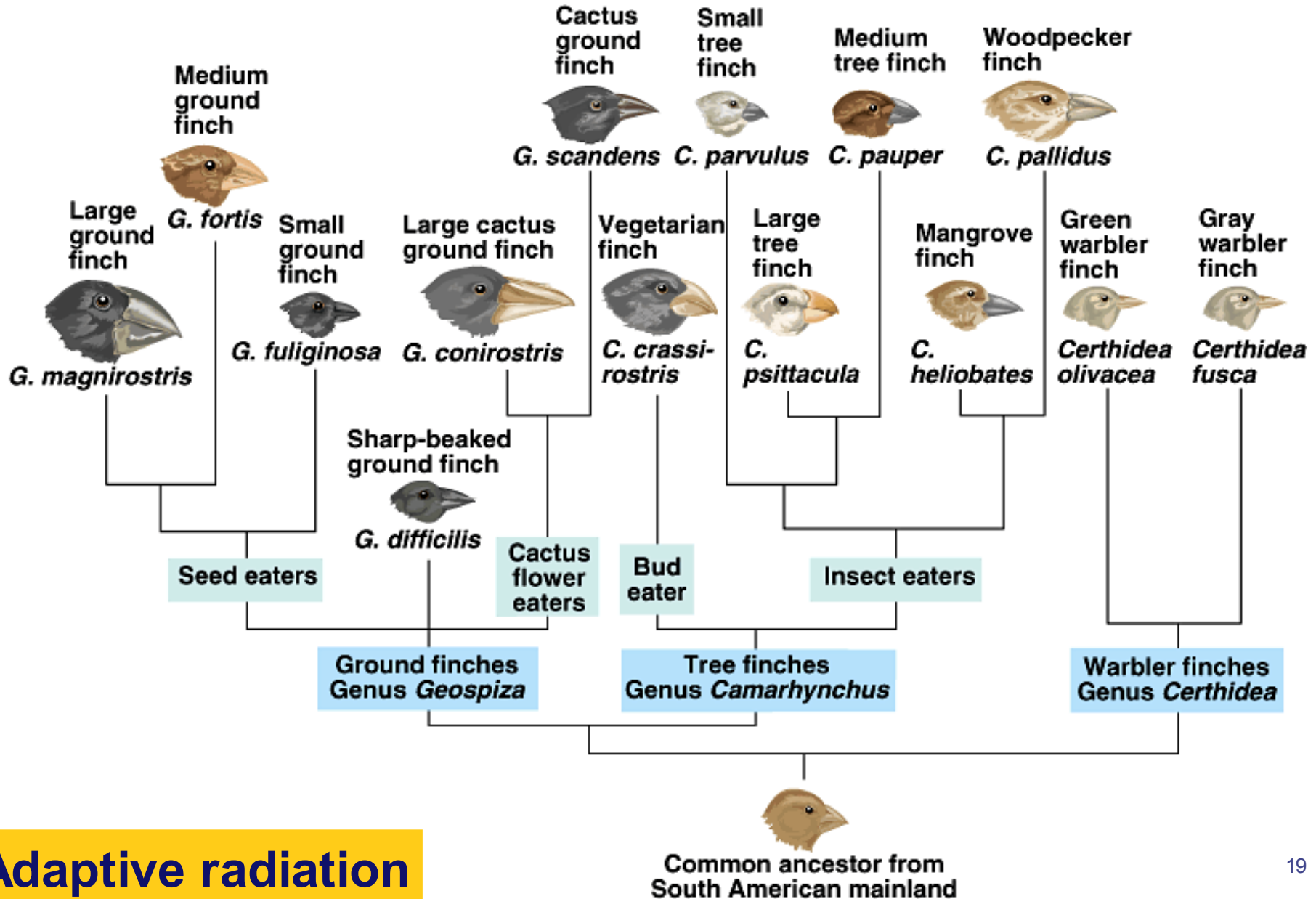
- Darwin was amazed to find out they were all finches
  - ◆ 14 species
  - ◆ but only one species on mainland of South America
    - 800 km away
  - ◆ all presumably originated from mainland

Large-seed eater?

Small-seed eater?

QuickTime™ and a  
Photo - JPEG decompressor  
are needed to see this picture.

# Correlation of species to food source



**Adaptive radiation**

# Darwin's finches



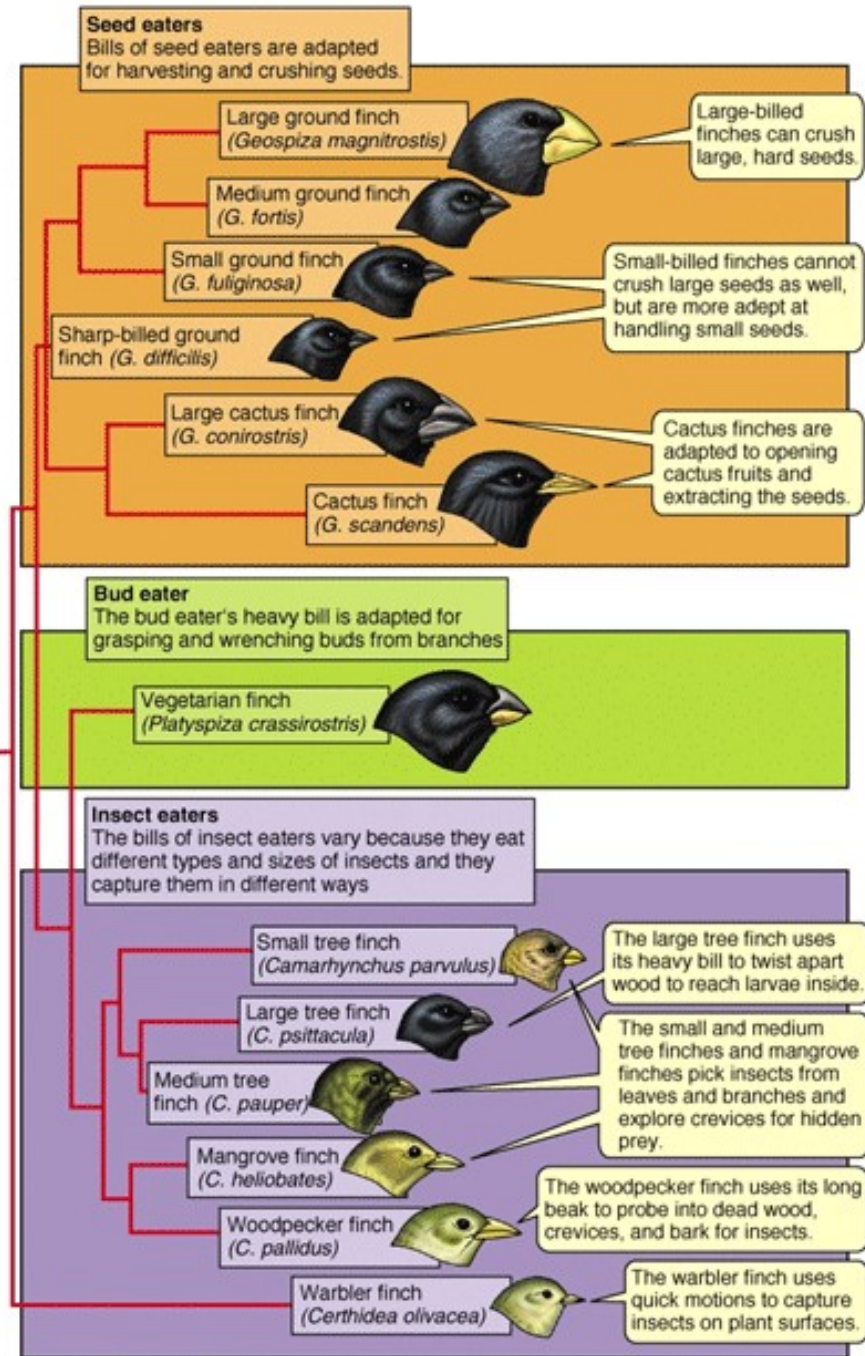
- **Differences in beaks**
  - ◆ associated with eating different foods
  - ◆ adaptations to foods available on islands
- **Darwin's conclusions**
  - ◆ when original South American finches reached islands, adapted to available food in different environments
  - ◆ over many generations, the finches changed anatomically & behaviorally
    - accumulation of favorable traits
    - emergence of different species



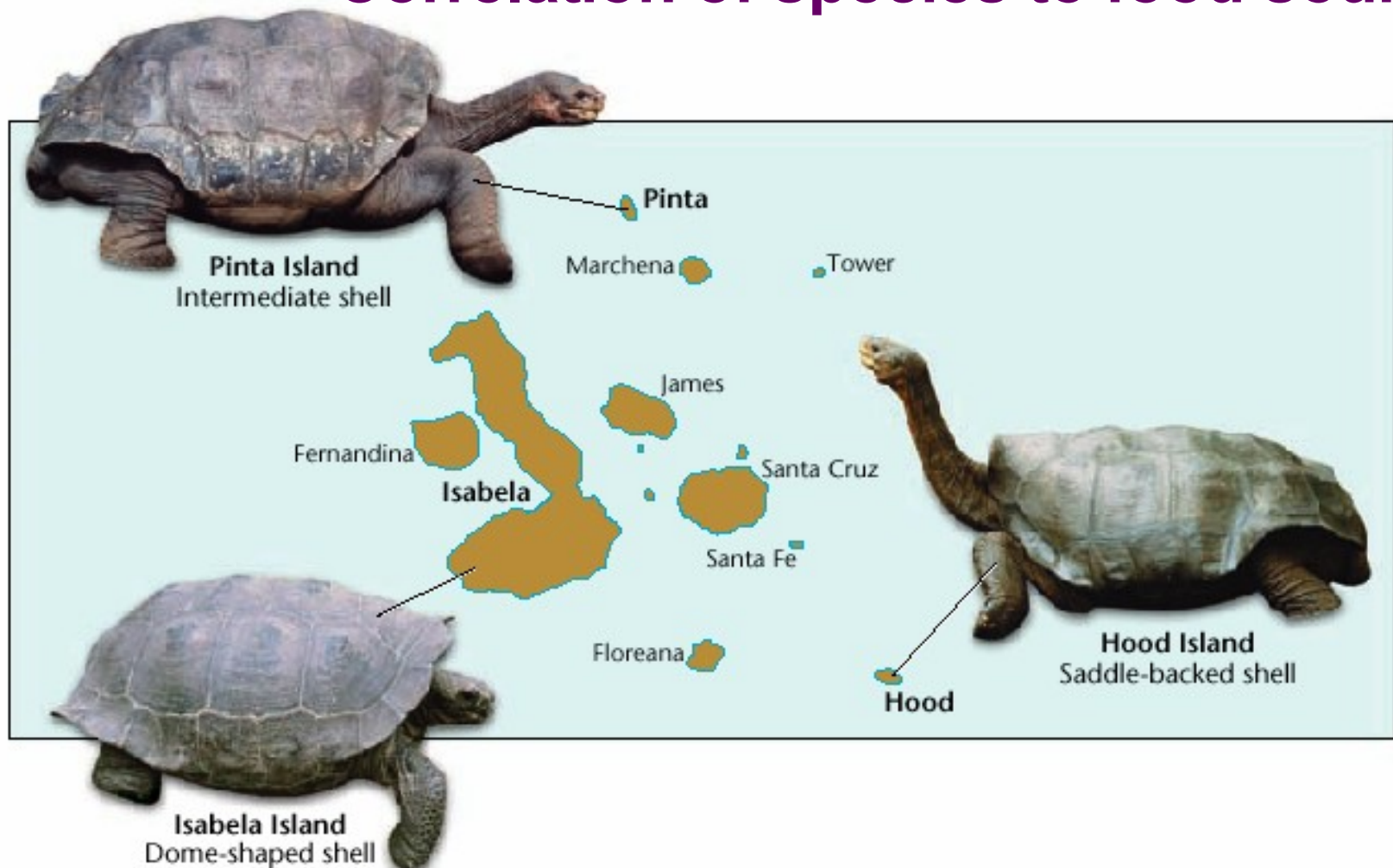
# Darwin's finches

- Finches with beak differences that allowed them to...
  - successfully feed
  - successfully compete
  - successfully reproduce
    - pass successful traits onto their offspring

ANCESTOR FINCH  
from South America  
mainland.

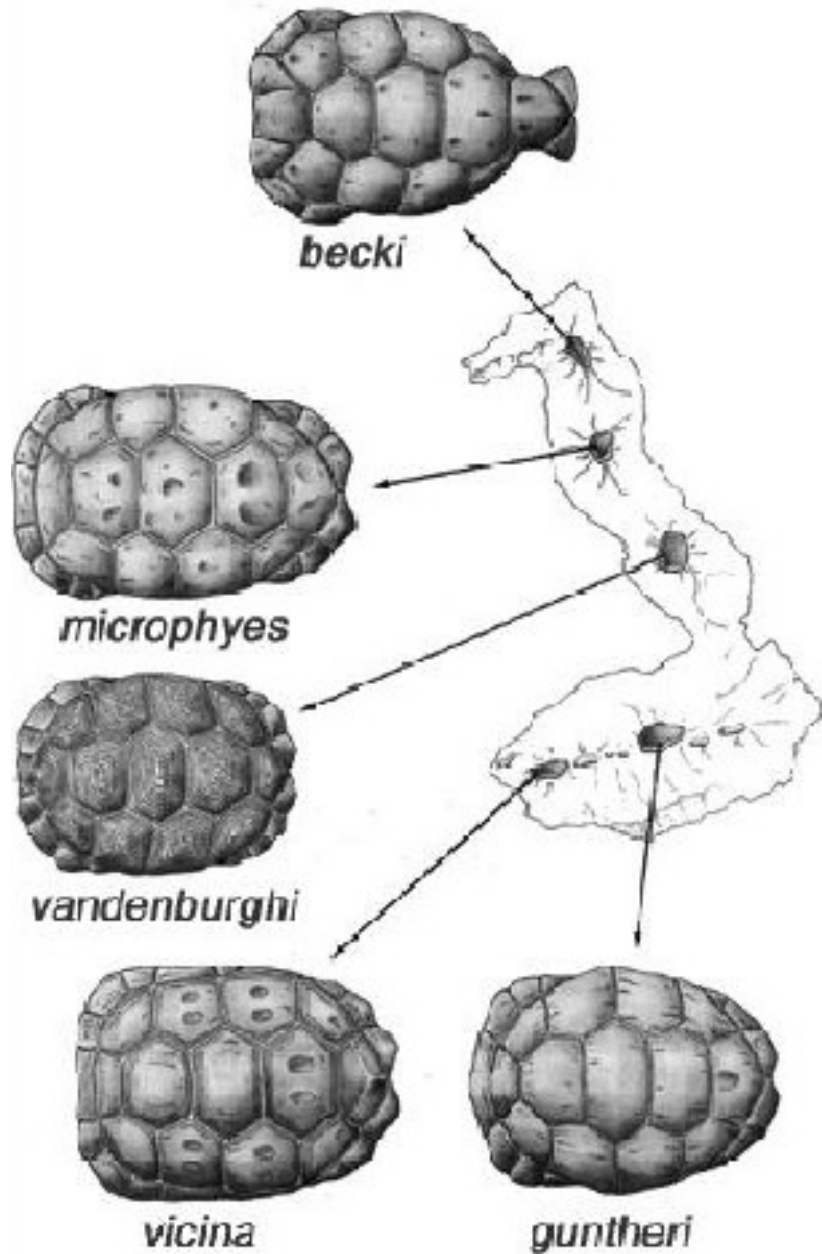


# Correlation of species to food source



© D.Cavagnaro/DRK Photo • © M.Cavagnaro/DRK Photo

**Variation Among Tortoises** 🌿 Darwin observed that the characteristics of many animals and plants varied noticeably among the different Galápagos Islands. Among the tortoises, the shape of the shell corresponds to different habitats. The Hood Island tortoise (right) has a long neck and a shell that is curved and open around the neck and legs, allowing the tortoise to reach the sparse vegetation on Hood Island. The tortoise from Isabela Island (lower left) has a dome-shaped shell and a shorter neck. Vegetation on this island is more abundant and closer to the ground. The tortoise from Pinta Island has a shell that is intermediate between these two forms.



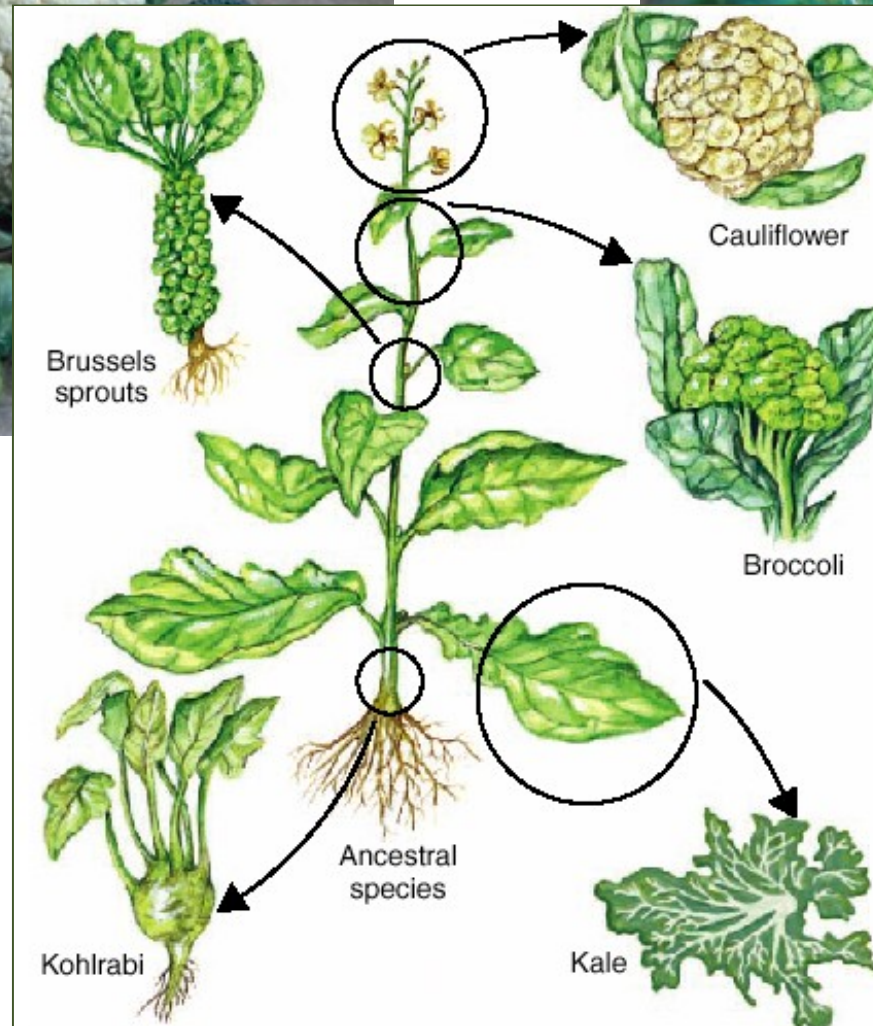
**Many islands show distinct local variations in tortoise morphology...**

**... perhaps these are the first steps in the splitting of one species into several?**





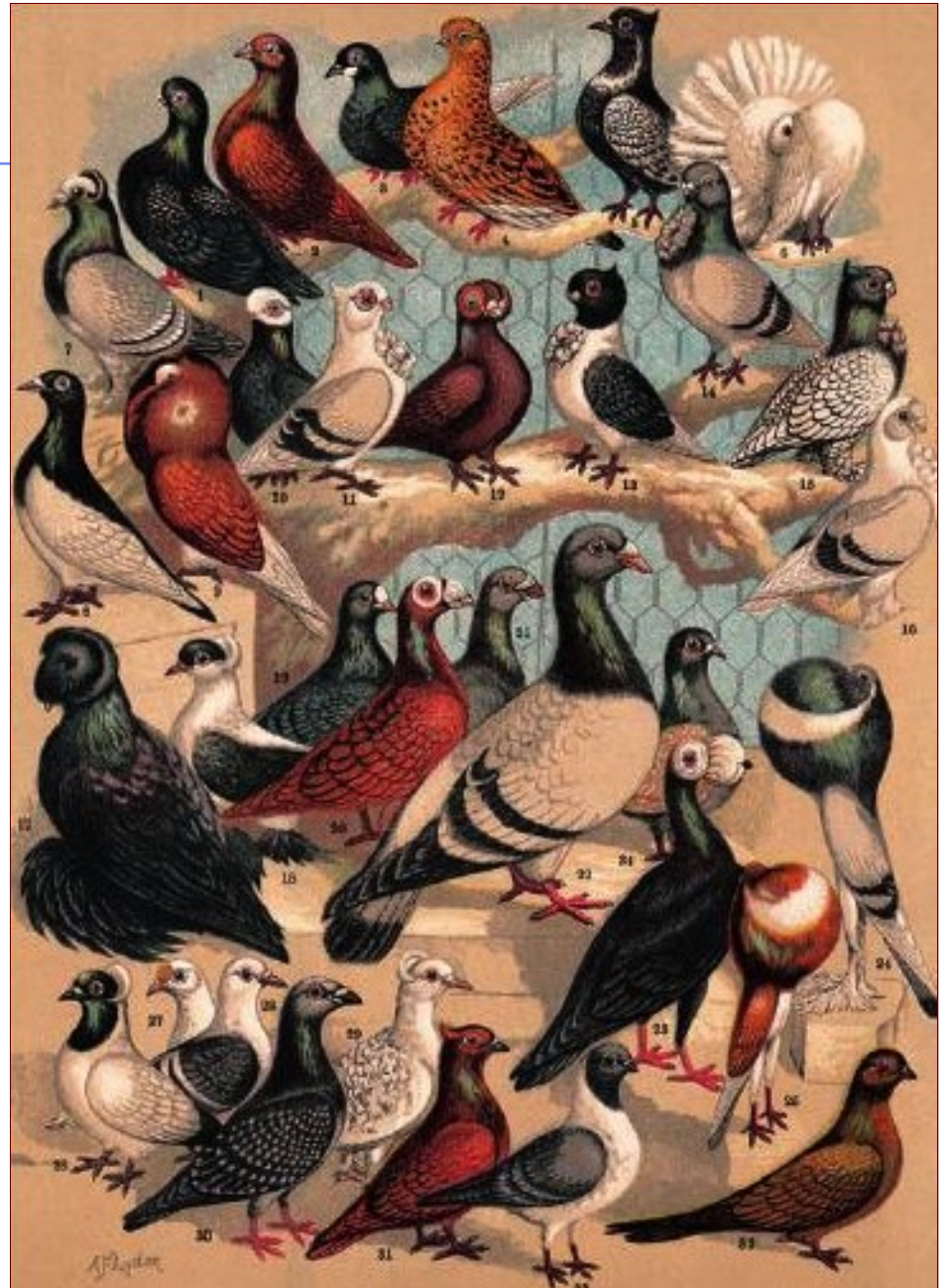
**This is not just  
a process of  
the past...**



**It is all  
around us  
today**

# Selective breeding

the raw genetic material is hidden there





# Selective breeding

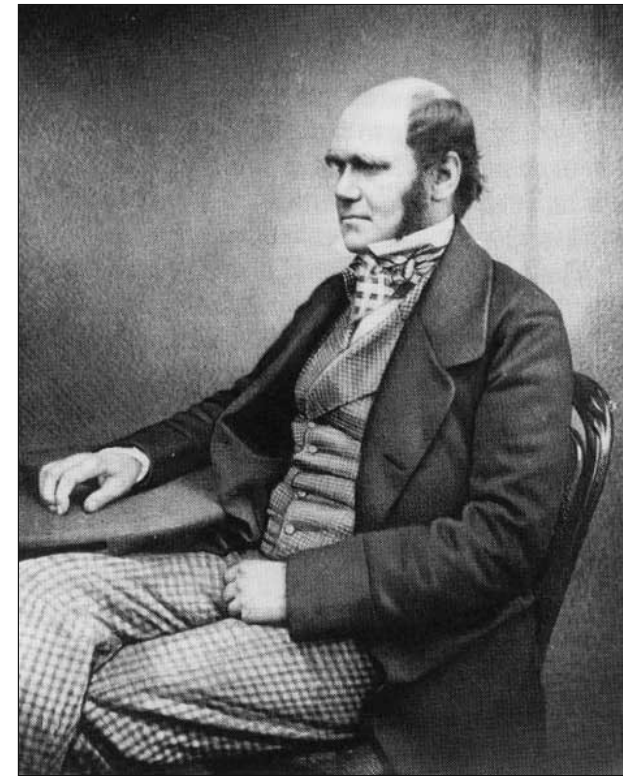
**Broad variation!**





# A Reluctant Revolutionary

- Returned to England in 1836
  - ◆ wrote papers describing his collections & observations
  - ◆ long treatise on barnacles
  - ◆ draft of his theory of species formation in 1844
    - instructed his wife to publish this essay upon his death
    - reluctant to publish but didn't want ideas to die with him

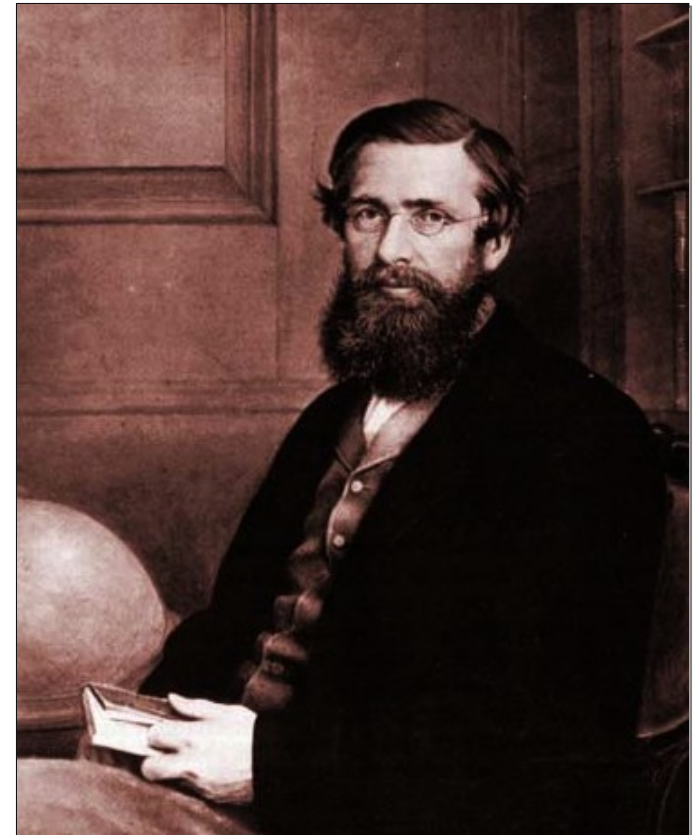


# And then came the letter....

Then, in 1858, Darwin received a letter that changed everything...

## Alfred Russel Wallace

a young naturalist working in the East Indies, had written a short paper with a new theory. He asked Darwin to evaluate his theory and pass it along for publication.



2005-2006

## Darwin wrote to Lyell:

*"Your words have come true with a vengeance... I never saw a more striking coincidence... so all my originality, whatever it may amount to, will be smashed."*

### 1858 ON THE TENDENCY OF VARIETIES TO DEPART INDEFINITELY FROM THE ORIGINAL TYPE

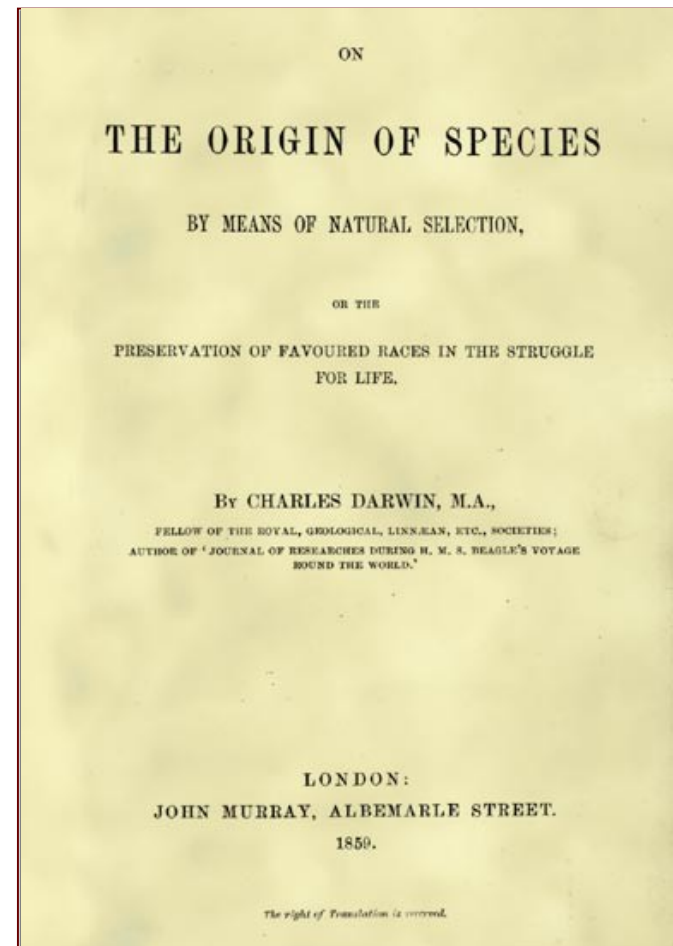
by Alfred Russel Wallace written at Ternate, February, 1858  
**Instability of Varieties supposed to prove the permanent distinctness of Species**

ONE of the strongest arguments which have been adduced to prove the original and permanent distinctness of species is, that varieties produced in a state of domesticity are more or less unstable, and often have a tendency, if left to themselves, to return to the normal form of the parent species; and this instability is considered to be a distinctive peculiarity of all varieties, even of those occurring among wild animals in a state of nature, and to constitute a provision for preserving unchanged the originally created distinct species.

In the absence of scarcity of facts and observations as to varieties occurring among wild animals, this argument has had great weight with naturalists, and has led to a very general and somewhat prejudiced belief in the stability of species. Equally general, however, is the belief in what are called "permanent or true varieties,"- races of animals which continually propagate their like, but which differ so slightly (although constantly) from some other race, that the one is considered to be a variety of the other. Which is the variety and which the original species, there is generally no means of determining, except in those rare cases in which the one race has been known to produce an offspring unlike itself and resembling the other. This, however, would seem quite incompatible with the "permanent invariability of species," but the difficulty is overcome by assuming that such varieties have strict limits, and can never again vary further from the original type, although they may return to it, which, from the analogy of the domesticated animals, is considered to be highly probable, if not certainly proved.

It will be observed that this argument rests entirely on the assumption, that varieties occurring in a state of nature are in all respects analogous to or even identical with those of domestic animals, and are governed by the same laws as regards their permanence or further variation. But it is the object of the present paper to show that this assumption is altogether false, that there is a general principle in nature which will cause many varieties to survive the parent species, and to give rise to successive variations departing further and further from the original type, and which also produces, in domesticated animals, the tendency of varieties to return to the parent form.

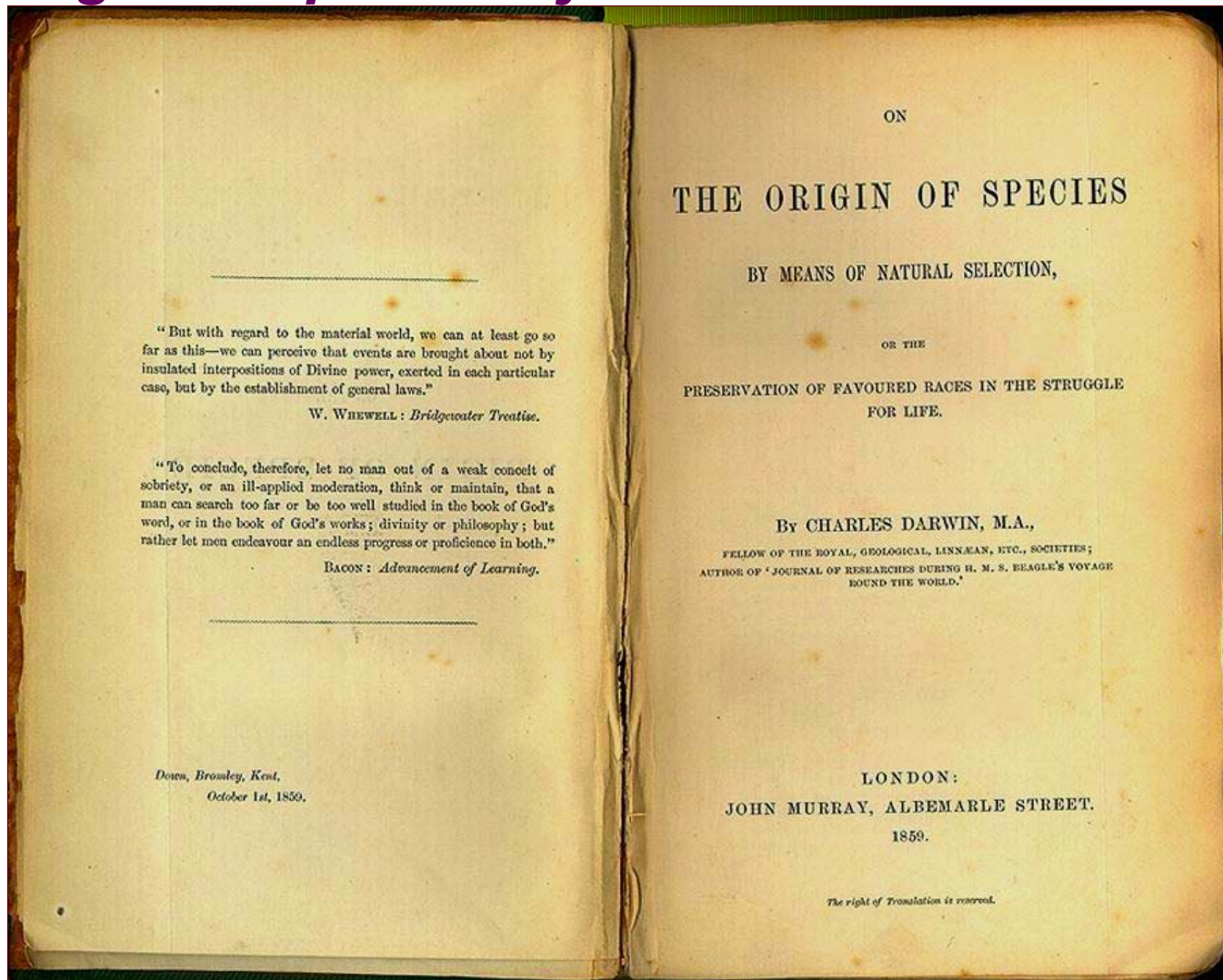
The Struggle for Existence.





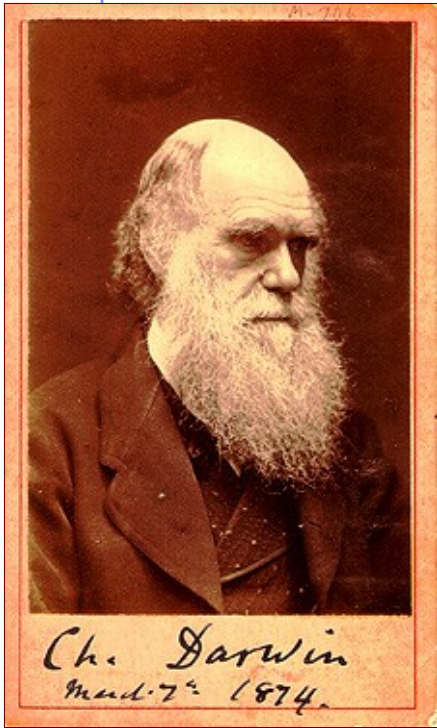
November 24, 1859, Darwin published

*“On the Origin of Species by Means of Natural Selection”*



# Essence of Darwin's ideas

- His theory was simple...



(1) **Variation** exists in natural populations

(2) Many **more offspring** are born each season than can possibly survive to maturity

(3) As a result, there is a **struggle for existence**

(4) **Characteristics beneficial** in the struggle for existence will tend to become more common in the population, changing the characteristics of a species

(5) Over time, and given a steady input of new variation into a population, these processes lead to the **emergence of new species**

# LaMarckian vs. Darwinian view

## ■ LaMarck

- ◆ giraffe's “need” to reach higher vegetation stretches their neck & stimulates transmission of longer neck to offspring



## ■ Darwin

- ◆ long-necked giraffes survive better & leave more offspring with genes for long necks





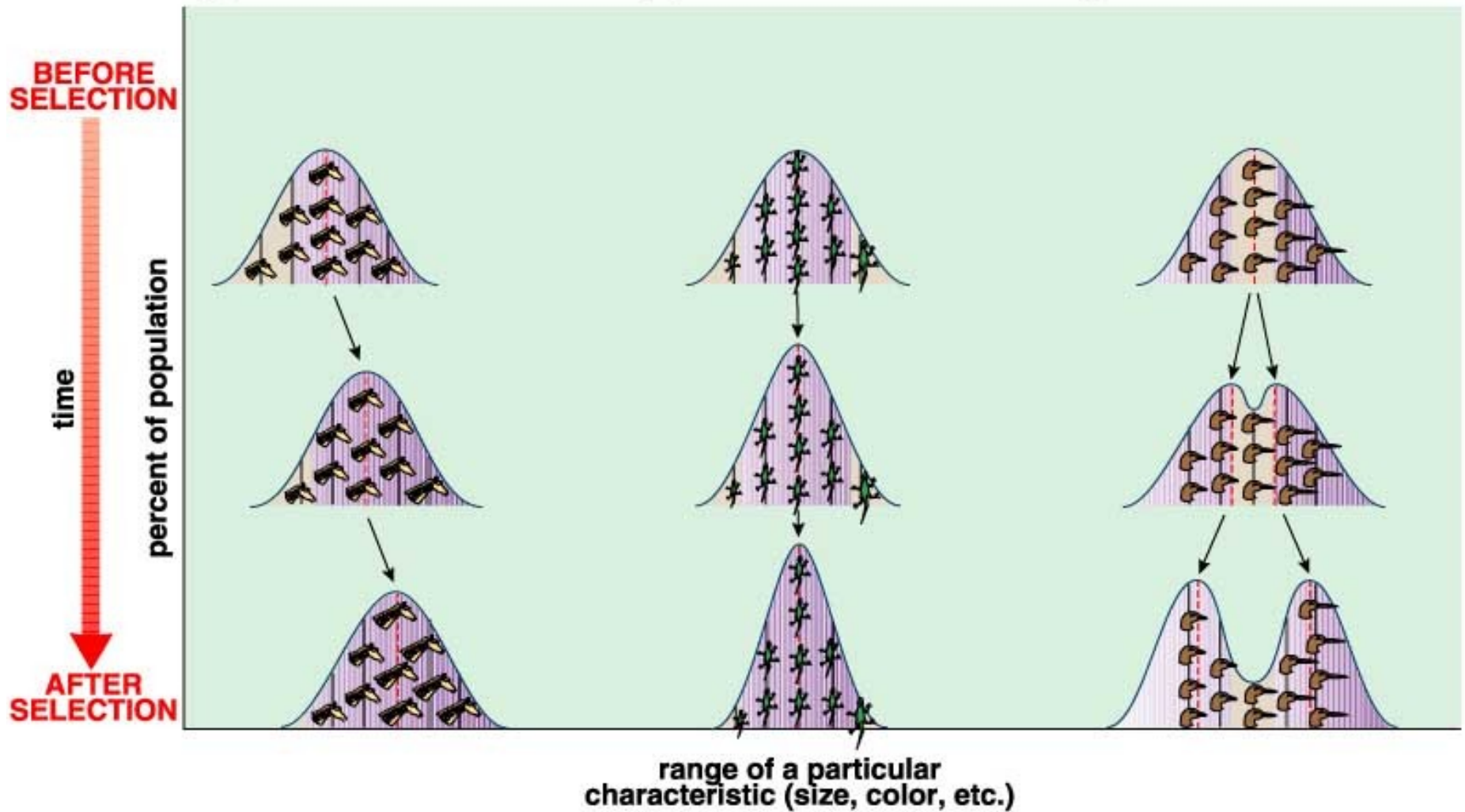
# Natural Selection

- Darwin referred to all of these factors together as natural selection
  - ◆ variation
  - ◆ production of more offspring than can survive
  - ◆ competition
    - for food, for mates & nesting spots, to escape predators
  - ◆ differential survival based on traits



"Listen... I'm fed up with this 'weeding out the sick and the old' business... I want something in its prime."

(a) DIRECTIONAL SELECTION (b) STABILIZING SELECTION (c) DISRUPTIVE SELECTION

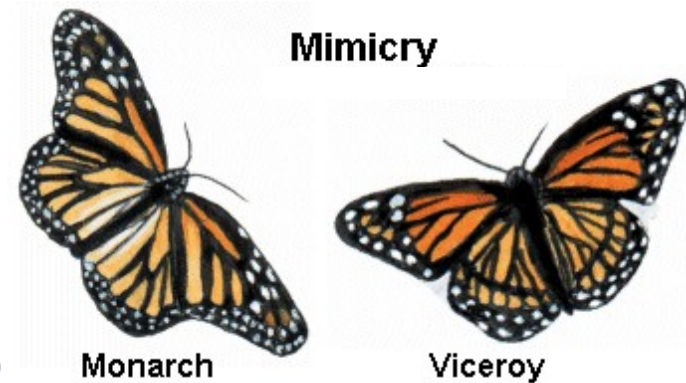


Natural selection can act in a number of directions

# Natural Selection can take several forms

## ■ Predation Selection

- ◆ camouflage (mimicry)
- ◆ speed
- ◆ behaviors & habits
- ◆ defenses (physical & chemical)





# Can you find the mantis?

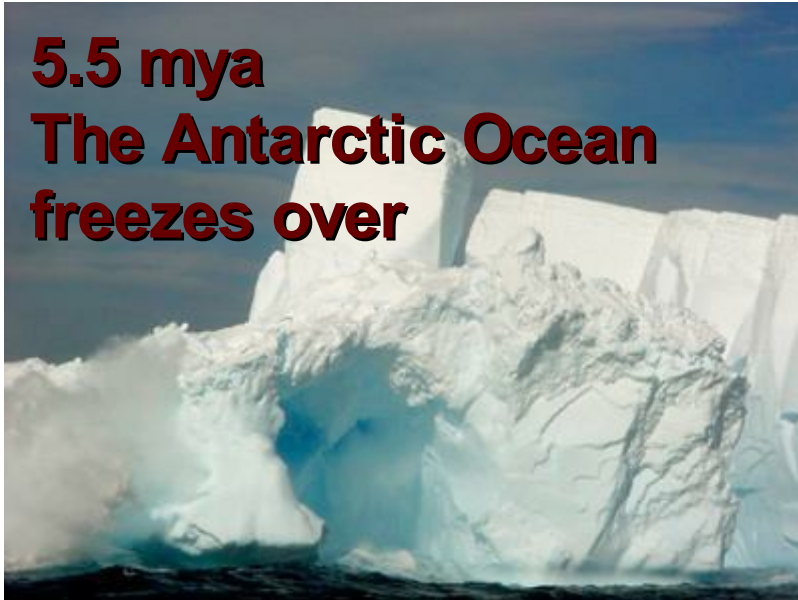


# Natural Selection can take several forms

## ■ Physiological Selection

- ◆ fitness (food-gathering)
- ◆ physiology efficiency (oxygen, food, water)
- ◆ disease resistance
- ◆ protection from injury
- ◆ biochemical versatility

**5.5 mya**  
**The Antarctic Ocean**  
**freezes over**

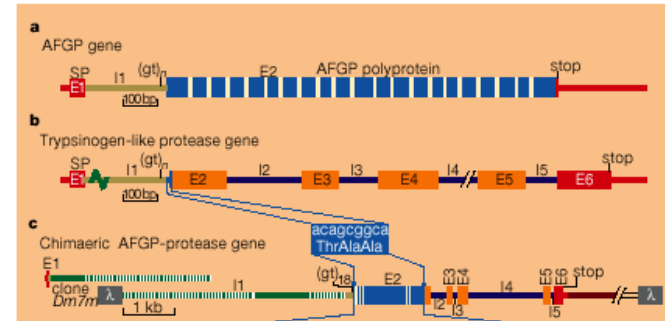


## Evolution of an antifreeze glycoprotein

A blood protein that keeps Antarctic fish from freezing arose from a digestive enzyme.

The ice-binding antifreeze glycoprotein (AFGP) that circulates in the blood of Antarctic notothenioid fishes enables them to avoid freezing in their perpetually icy environment<sup>1</sup>. This crucial survival protein probably arose from a functionally unrelated pancreatic trypsinogen-like protease<sup>2</sup>. We have now discovered an important intermediate in this evolutionary process — transcriptionally active chimaeric genes that encode both an AFGP polypeptide and the protease, confirming the protease origin of AFGP and indicating how it was created.

AFGP binds to and arrests the growth of ice crystals, preventing the fish from freezing. There are at least six different sizes of repeats of monomer (ThrAlaAla) attached to the



**Some Fish adapt by evolving antifreeze proteins.**

# Physiological selection

Dogs pee on trees...Why don't trees pee on dogs?





# Natural Selection can take several forms

## ■ Sexual Selection

- ◆ attractiveness to potential mate
- ◆ fertility of gametes
- ◆ “ultimately, differential reproductive success”

**“survival” doesn’t matter if you don’t reproduce!**  
*(meaning: attract mate & breed)*



# Sexual selection





# What's a lion's mane for?

Science magazine

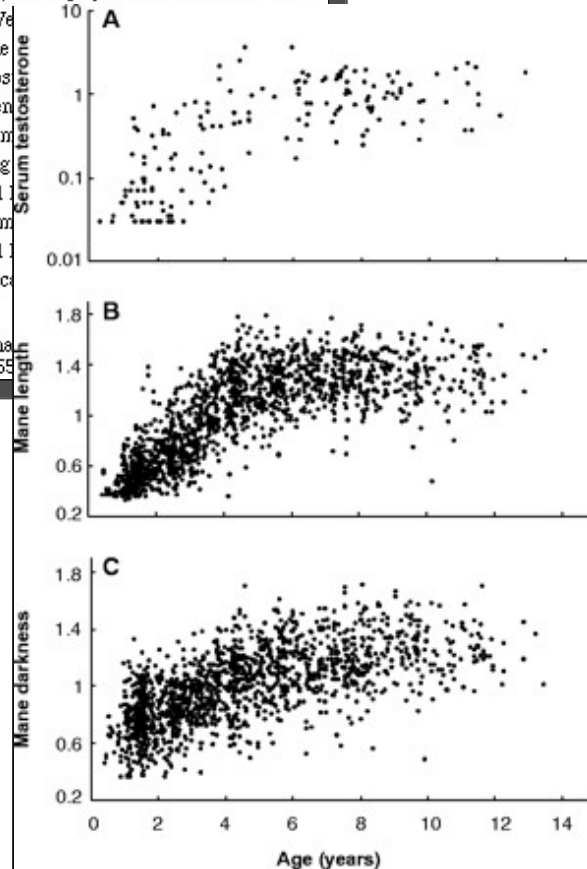
HELP SUBSCRIPTIONS FEEDBACK  
SEARCH BROWSE

## Sexual Selection, Temperature, and the Lion's Mane

Peyton M. West\* and Craig Packer

The mane of the African lion (*Panthera leo*) is a highly variable trait that reflects male condition and ambient temperature. We report variation in a long-term study of lions in the Serengeti. Mane darkness indicates nutrition and testosterone levels, and male-male competition. Mane length only appears to influence male-male assessment of reproductive life-spans and higher offspring surface temperatures, abnormal sperm, and shorter manes in hotter seasons, years, and of the year. Maned males are hotter than females. Shorter manes in hotter seasons, years, and of the year suggests that the mane will respond to forecast temperature.

Department of Ecology, Evolution and Behavior  
1987 Upper Buford Circle, St. Paul, MN 55105



Hello, handsome. Female lions prefer males with dark manes, but such decoration comes at a cost.

**Larger, darker mane correlates with good nutrition, health, and high testosterone levels.**

**It also imposes a cost on the individual (*it's hot!*).**

**Meaning??**

***"If he can deal with that mane, he must be very fit!"***



# Sexual selection

- Sexual selection acts in all sexually-reproducing species
  - ◆ it influences morphology & behavior
  - ◆ it acts on both males and females





**Evolution is "so overwhelmingly established that it has become irrational to call it a theory."**

**-- Ernst Mayr  
What Evolution Is  
2001**

**Professor Emeritus, Evolutionary Biology  
Harvard University  
(1904-2005)**

**2005-2006**



A decorative graphic consisting of two blue lines, one horizontal and one vertical, intersecting at a small blue circle. This graphic is positioned in the top-left corner of the slide. Another identical graphic is positioned in the bottom-right corner of the slide.

**Any Questions??**